**CHBE 501, Transport Phenomena, Fall 2015**

Meeting: 10:00 AM MWF; Mechanical Lab 254
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Textbooks: Aris, *Vectors, Tensors and the Basic Equations of Fluid Mechanics*

Bird, Stewart, and Lightfoot, *Transport Phenomena*

- Computing languages
  - MATLAB
  - FORTRAN
- Grading: Assigned problems and examinations; each exam, (at least one), will be 25% of the total grade.
- Each assigned problem will have due date, usually the first class periods after assignment. Solution will be distributed. Students will self-grade on 0 – 100 scale.
- Problems turned in next class period after due date or reworked will be credited 80% of maximum score on reworked portion. Self-grade and put original and reworked scores on paper and hand-in. Teaching Assistant will audit grading and post in OwlSpace score-sheet.
- Collaborative discussions are encouraged on assigned problems only if you have difficulty. However, each student should turn in only their own work.
- Some assignments will be team projects.

Assistance: If you have difficulty with lecture material or assigned problem, first discuss with another student. If two or more students cannot resolve problem, see Professor Hirasaki or teaching assistant.

Misc.: Please point out error in notes and suggestions for improvements are welcome.

**CHBE 501 Transport Phenomena**

**1. Introduction**

**Prerequisites and text books**
**Scalar, vector and tensor fields**
**Curves, surfaces, and volumes**
**Coordinate systems**
**Continuum approximation**
**Densities, potential gradients, and fluxes**

**2. Cartesian Vectors and Tensors: Their Algebra**

**Definition of a vector**
**Examples of vectors**
**Scalar multiplication**

**Addition of vectors - Coplanar vectors**
**Unit vectors**
**A basis of non-coplanar vectors**
**Scalar product - Orthogonality**
**Directional cosines for coordinate transformation**
**Vector product**
**Velocity due to rigid body rotations**
**Triple scalar products**
**Triple vector products**
**Second order tensors**
**Examples of second order tensors**
**Scalar multiplication and addition**
**Contraction and multiplication**
**The vector of a antisymmetric tensor**
**Canonical form of a symmetric tensor**

**3. Cartesian Vectors and Tensors: Their Calculus**

**Tensor functions of time-like variable**
**Curves in space**
**Line integrals**
**Surface integrals**
**Volume integrals**
**Change of variables with multiple integrals**
**Vector fields**
**The vector operator del - gradient of a scalar**
**The divergence of a vector field**
**The curl of a vector field**
**Green's theorem and some of its variants**
**Stokes' theorem**
**The classification and representation of vector fields**
**Irrotational vector fields**
**Solenoidal vector fields**
**Helmholtz' representation**
**Vector and scalar potential**

**4. The Kinematics of Fluid Motion**

**Particle paths and material derivatives**
**Streamlines**
**Streaklines**
**Dilatation**
**Reynolds' transport theorem**
**Conservation of mass and the equation of continuity**
**Deformation and rate of strain**
**Physical interpretation of the deformation tensor**
**Principal axis of deformation**
**Vorticity, vortex lines, and tubes**

**5. Stress in Fluids**

- **Cauchy's stress principle and the conservation of momentum**
- **The stress tensor**
- **The symmetry of the stress tensor**
- **Hydrostatic pressure**
- **Principal axes of stress and the notion of isotropy**
- **The Stokesian fluid**
- **Constitutive equations of the Stokesian fluid**
- **The Newtonian fluid Interpretation of the constants**

**6. Equations of Motion and Energy in Cartesian Coordinates**

- **Equations of motion of a Newtonian fluid**
- **The Reynolds number**
- **Dissipation of energy by viscous forces**
- **The energy equation**
- **The effect of compressibility**
- **Resume of the development of the equations**
- **Special cases of the equations**
- **Boundary conditions**
- **Scaling, dimensional analysis, and similarity**
- **Bernoulli theorems**

**7. Solution of the Partial Differential Equations**

- **Classes of partial differential equations**
- **Systems described by diffusion equation**
- **Greens function, convolution, and superposition**
- **Green's function for the diffusion equation**
- **Fourier transform method**
- **Convective-diffusion equation**
- **Similarity transformation**
- **Complex potential for irrotational flow**
- **Solution of hyperbolic systems**

**8. Laminar Flows with Dependence on One Dimension**

- **Couette flow**
- **Poiseuille flow**
- **Steady film flow down inclined plane**
- **Unsteady viscous flow**

**9. Multidimensional Laminar Flows**

- **Lubrication and film flow**
- **Laminar boundary layer**
- **Creeping flow in wedge**
- **Flow around particle**

**10. Flow through Porous Media**

**11. Flow with Free Surface**

- **Boundary conditions at a fluid-fluid interface**
- **Static gravity - capillary equilibrium**
- **Dynamics of viscous, capillary, gravity flow**
- **Film drainage and deposition with Laplace pressure**

**12. Numerical Simulation (if time allows)**

- **The stream function - vorticity method**
- **Finite difference approximation**
- **Solution of linear equations**
- **FORTRAN on Owlnet**
- **Transients and finite Reynolds numbers**
- **Calculation of pressure and stress**
- **Cylindrical-polar coordinates**
- **Flow past cylinder**